It's a Breeze
How Air Pressure Affects You

Results from Air Pressure Experiments

Click here to do the experiments, or find out more about air pressure.

Experiment #1

Your chest expands because, like blowing up a balloon, you are increasing the number of air molecules inside your lungs. This causes your lungs to expand in order to provide space for the increased number of air molecules.

Experiment #2

When a balloon is blown up, the air pressure *inside* the balloon slowly becomes greater than the air pressure *outside* the balloon. Since the balloon is made of rubber and is expandable, it grows larger and larger. When the balloon is popped, the air escapes instantly. The sound you hear is from the molecules of air inside the balloon coming into sudden contact with the molecules of air outside the balloon.

Experiment #3

The milk jug will crumple in on itself. When you added the hot water, it caused the air temperature inside the jug to rise. While the container was sealed no air could get into or out of the jug. When the water inside the jug cooled, the air cooled and caused the pressure inside the jug to decrease.

As the pressure on the inside walls of the jug decreased, the walls of the jug collapsed. Since there wasn't enough air pressure inside the jug to offset the air pressure on the outside of the jug!

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be sure to check out Lou's book: How Things Work, The Physics of Everyday Life

submit a question to Dr. Lou

Q **Why do mylar balloons lose or seem to lose helium when taken outside in the cold and blow back up or seem to blow back up when you take them back in where it is warm? —** TS, Alabama

A Since the balloon is sealed, the number of helium atoms it contains doesn't change when you cool it or warm it. However, that doesn't mean that the balloon's size is fixed. What you are observing here is the relationship between three important properties of a trapped gas: its temperature, its pressure, and its volume. As you cool the balloon, its volume shrinks so as to keep its internal pressure in balance with the surrounding air pressure. When you later heat the balloon, its volume increases to maintain this same pressure balance.

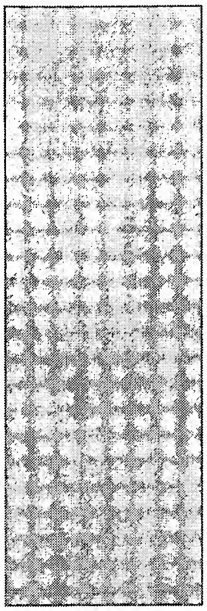
The pressure that a fixed quantity of gas exerts on its container is determined by two things: (1) that gas's temperature and (2) how densely packed its particles are. Since temperature is related to speed of motion in the gas particles, the particles in a hotter gas hit their container harder and more often than those in a cooler gas and they exert more pressure on that container. Similarly, the particles in a more densely packed gas hit each unit of container surface more often than those in a more dilute gas and thus exert more pressure. Overall, the pressure that a fixed quantity of gas exerts on its container is proportional to the gas's temperature (more on how to measure this temperature in a minute) and to its packing density.

When you take your helium balloon outside

and it cools off, the pressure in the balloon begins to drop as its gas atoms slow down. Because the balloon is surrounded by air at atmospheric pressure, the balloon begins to experience a pressure imbalance that crushes the balloon inward. As the balloon shrinks from this imbalance and its volume decreases, the helium atoms inside it become more tightly packed. That increasing packing density raises the helium's pressure and eventually stops the balloon from shrinking further. Thus for a given decrease in gas temperature, there is a specific decrease in balloon volume that balances it and allows the balloon's internal pressure to equal the atmospheric pressure surrounding the balloon.

When you later return the chilled balloon to the warm indoors, its trapped helium atoms warm up and become more effective at producing pressure. They push the balloon's skin outward against the surrounding air pressure and the balloon expands. As it expands, its atoms spread out and become more dilute. They become less effective at producing pressure and the balloon again reaches a specific size at which the balloon's internal pressure exactly balances the atmospheric pressure surrounding the balloon.

Finally, a word about temperature and gas properties. In an "ideal gas"—a gas in which the particles don't stick to one another at all—the pressure is exactly proportional to the temperature times the packing density of the particles. Helium is nearly an ideal gas, so it follows this behavior beautifully. Since the packing density of a trapped gas is inversely proportional to that gas's volume, the temperature of the gas is proportional to the gas's pressure times its volume. In a balloon, the compressing effects of the surrounding air makes sure that the balloon's internal pressure stays constant. So as the balloon's temperature decreases, so does the balloon's volume. One is exactly proportional to the other.



But the temperature we are talking about here is measured in what is known as an "absolute temperature scale"—a scale in which the zero of temperature is the true zero: **absolute zero**—the temperature at which all thermal energy has been removed from the system (-459° F or -273° C). The standard absolute temperature scale is the Kelvin scale or K. Room temperature is about 300 K. If you were to take your balloon into a 150 K environment (about -190° F), it would shrink to exactly half its original volume.

GAS PRESSURE

Introduction:

Pressure is determined by the flow of mass from a high pressure region to a low pressure region. Pressure measurements are made on the fluid states--liquids and gases. Air exerts a pressure which we are so accustomed to that we ignore it. The pressure of water on a swimmer is more noticable. You may be aware of pressure measurements in relations to the weather or your car or bicycle tires.

What is pressure?

PRESSURE is a force exerted by the substance per unit area on another substance. The pressure of a gas is the force that the gas exerts on the walls of its container. When you blow air into a balloon, the balloon expands because the pressure of air molecules is greater on the inside of the balloon than the outside. Pressure is a property which determines the direction in which mass flows. If the balloon is released, the air moves from a region of high pressure to a region of low pressure.

Atmospheric pressure varies with height just as water pressure varies with depth. As a swimmer dives deeper, the water pressure increases. As a mountain climber ascends to higher altitudes, the atmospheric pressure decreases. His body is compressed by a smaller amount of air above it. The atmospheric pressure at 20,000 feet is only one-half of that at sea level because about half of the entire atmosphere is below this elevation.

Atmospheric pressure at sea level can be expressed in terms of 14.7 pounds per square inch. The pressure in car or bicycle tires is also measured in pounds per square inches. A car should have 26-30 lb/sq.in. and bicycle tires 40-60/sq.in.

BAROMETER:

The weatherman is likely to give atmospheric pressure or barometric pressure as 30 inches. This type of measurement is made with a Torricelli barometer. It consists of a long tube closed at one end, filled with mercury and inverted in a vessel of mercury as shown in Figure 4.

At sea level, the force of the atmospheric pressure will support a column of mercury 760 mm in height. Actually, the weight of the column of mercury is equal to the force of the atmospheric pressure.

In a similar fashion, atmospheric pressure forces water in a similar column up
to 34 feet high!

Simple Pressure Related Applications:

DRINKING STRAW: A drinking straw is used by creating a suction with your mouth. Actually this causes a decrease in air pressure on the inside of the straw. Since the atmospheric pressure is greater on the outside of the straw, liquid is forced into and up the straw.

SIPHON: With a siphon water can be made to flow "uphill". A siphon can be started by filling the tube with water (perhaps by suction). Once started, atmospheric pressure upon the surface of the upper container forces water up the short tube to replace water flowing out of the long tube.

Boyle's Law:

In 1662 Robert Boyle made the first systematic study of the relationship

between volume and pressure in gases. Boyle's observations can be summed up in the statement: At constant temperature, the volume of a gas varies inversely with the pressure exerted on it.

Figure 6. BOYLE'S LAW DEMONSTRATION

Kinetic Molecular Theory Explanation of Boyle's Law

Observations about pressure may be explained using the following ideas. The rapid motion and collisions of molecules with the walls of the container causes pressure (force on a unit area). Pressure is proportional to the number of molecular collisions and the force of the collisions in a particular area. The more collisions of gas molecules with the walls, the higher the pressure.

Demonstrations:
Antigravity
Hanging water
Magic Leaky Bottle - bottle with holes
Upside down glass in water
Battle of Two Balloons
Balloon Blown Up inside Bottle
Film Can Space Shuttle
King Kong's Hand